Management and Business Research Quarterly

MBRQ

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Management and Business Research Quarterly

2018(6)39–49

EUROPEAN KNOWLEDGE DEVELOPMENT Ltd. EUROKD

Dynamic Correlation between Oil Price and the Stock Markets: Evidence from some Developed and Emerging Countries

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Received *12 September 2018* ***Accepted*** *20 November 2018*

ABSTRACT

The aim of this paper is to examine the dynamic correlation and volatility between energy prices and stock market for some developed and emerging countries namely China, Germany, Russia, UK, and the USA, using daily data for the period 5 September-2014 to 28 August-2015 and by applying the Orthogonal GJR-GARCH. The price of oil plays a strategic role in the global economy. Many studies have highlighted its different impacts on macroeconomic variables such as GDP growth, unemployment rate, inflation, the stock market, etc. We collect the energy prices from the Energy Information Administration (EIA), and the stock indices from Thomson Reuters Data Stream. Results show a strong positive correlation between the stock market and energy prices in Russia and USA. In addition, the SSE Composite index presents positive correlation with oil prices. Finally, both UK and in Germany the stock market index shows a lower and mixed correlation measures with all energy prices during the full period.

Keywords: *Oil prices, Stock markets, Orthogonal GJR-GARCH, Dynamic correlation*

Introduction

In recent years, the stock markets in developed and emerging countries fell, the Standard and Poor 500 largest US stocks, FTSE UK is also falling 3%, 11%, and 8% respectively. Indeed, the same decline is present in emerging markets like Shanghai Composite Index, Stock Exchange (SHCOMP) and the Russian stock market (MICEX) with 35%. In a developed country like Germany, the German stock index (DAX) was down about 8%. The global economy is extremely

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vulnerable to fluctuations in oil prices, given that the value of the price per barrel is among the most attractive in the financial market. Statistics show that the price of a barrel of oil has quadrupled since 2002, from $ 26 in 2002 to $ 107 in 2012. Prices fell from about $ 100 in September 2014 to less than $ 50 per barrel in August. 2015. It is currently between $ 40 and $ 50. In this new context, future market concerns about crude oil, following many new signs as the slowdown in the Chinese economy, the increased supply in the market, non-compliance with quotas by member countries of the OPEC (Organization of Petroleum Exporting Countries). During the period from September 2014 to September 2015, prices of energy were characterized by lower levels of -1.18, -1.35 and -0, 6 respectively for gasoline, New York heating oil stain port, kerosene and propane. We will consider, in the first section, the relationship between the price of WTI (West Texas Intermediate) and stock market indices for ten countries through an empirical analysis using a multivariate GARCH class of models using the daily data period of decline ranging from 5 September 2014 to 28 August 2015. The paper is organize as follows. In Section 2, we present a review of the literature on crude oil through long time series models. Section 3 presents the model and the methodology followed by the results and the discussion in Section 4, and finally, section 5 presents the main conclusion.

Literature review

The literature tells us from several authors that oil as raw material remains an important element in the world economy. Its price remains the first factor of tension on the international markets. Many studies have highlighted market, economic crises, etc. In this context, we can cite the works of Rasche and Tatom (1977), the various publications of Hamilton (1983, 1996, 2003, 2009, and 2013), Lee. et al (1995), Rotemberg and Woodford (1996), Eltony and Al-Awadi (2001), Brown and Yücel (2002), Blanchard and Gali (2007), Bjørland (2008).

In recent years, Wu and Sen (2011), Basher, Haug and Sadorsky (2012) have also been able to confirm this impact.

Adam et al (2015) try by using the LVAR causal model to examine the dynamics of the relationship between world crude oil prices and Indonesian stock market. The period was within January 1, 2004, to December 31, 2013. The results confirmed positive relationship in the long-term and in the short-term. Chun-Li Tsai (2015) carried out a similar analysis of the positive and negative response of U.S. stock medium-sized firms and big firms respectively to oil change over a period from January 1990 to December 2012. Barragán et al (2015) detected a stable correlation between oil and stock markets in the pre-crisis period while this relationship shows the highest correlation in crisis periods during the 2008 and 2011.

Elie Bouri (2015) used an ARMAX GARCH framework. The result confirms the relationship between oil price and the examined stock markets during the period 3 April 2003 to 11 December 2013.

A positive and negative risk spillover between the S&P 500 stock index and West Texas Intermediate (WTI) crude oil future returns during the period spanning September 1, 2004, to September 11, 2012 are find by Du and He (2015).

With regard to the Chinese stock market, Chen and Lv (2015) emphasized in their study a very strong positive dependence on the global crude oil market based on the extreme value theory (EVT) and using data from January 1, 2000 to April 14, 2014.

An investigation by using multivariate GARCH models between oil prices and the stock prices of clean energy and technology companies demonstrates a $1 of stock companies price can be hedged for 20 cents the crude oil (Perry Sadorskh, 2012).

Moreover, other studies have not found any effect of oil on stock markets see, Mollick and Assefa (2013) Apergis and Miller, 2009, Bachmeier (2008) and Nandha and Faff (2008), Henriques and Sadorsky, (2008), Wei (2003)**.** The relationships between crude oil prices and stock performances of alternative energy companies during the period from January 3, 2001 to May 31, 2010 shows a significant interdependence (Huang et al., 2011). Al janabi et al (2010) covered the period 2006 -2008 the Gulf Cooperation Council (GCC) for establishing weak relationship between the GCC stock markets opposite petrol and gold prices.

Model and Methodology

Source of Data

The analysis try to examine the dynamic correlation between stock market index and crude oil after period of oil prices decline less than 100 US$ spanning 05 sep-2014 to 28 August-2015. We select 5 stock market index, namely; the FTSE (UK), S&P500 (USA), Shanghai (China), DAX (Germany) and MICEX (Russia).

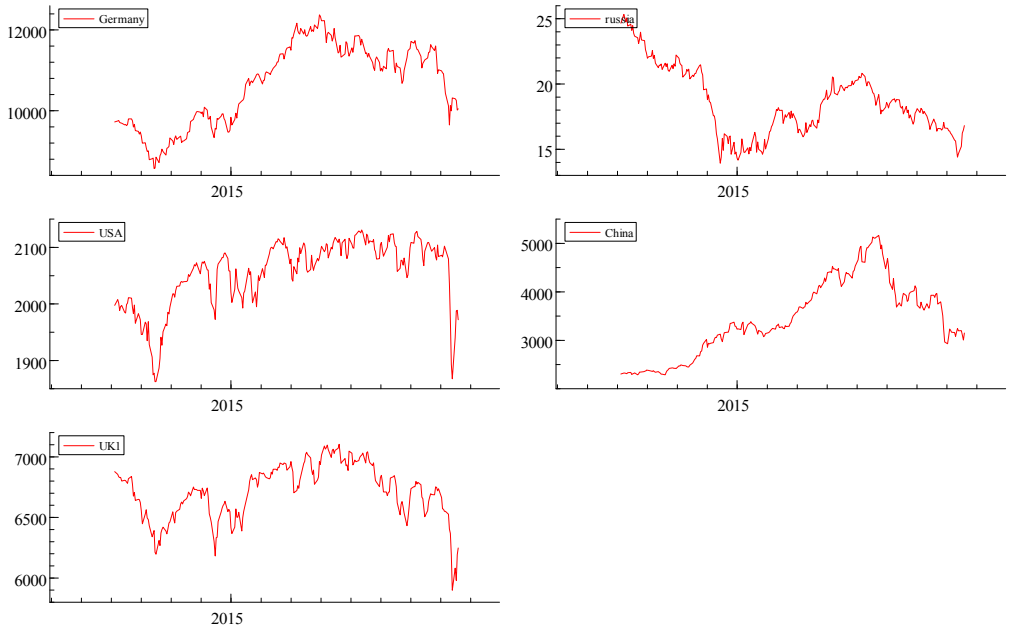

Figure 1: Stock markets

The second data set of energy prices includes WTI, U.S. Gulf Coast Kerosene, New York Oil Spot Price, Mont Belvieu, TX Propane Spot Price FOB and New York Diesel Spot Price.

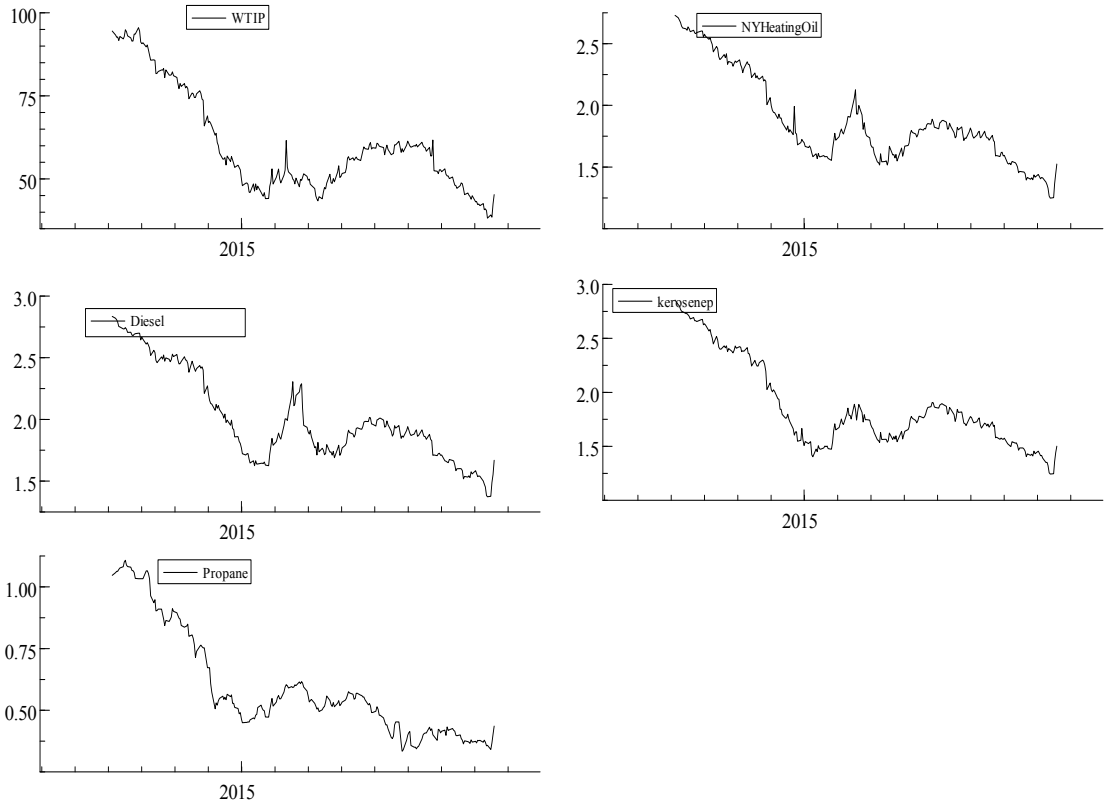

Figure 2: Energy prices

Energy prices are extracted from the Energy Information Administration (EIA), while stock indices from Thomson Reuters [Data Stream]. The return on each index defined as:

We calculate oil prices and stock index returns as:

$$R_{it} = ln(\frac{T_{it}}{T_{t-1}}) \ldots\ldots\ldots (1)$$

Where:

T_{it}: Energy prices and stock indices at time t

T_{t-1}: Energy prices and stock indices at time t-1

R_{it}: Return on Energy prices and stock indices at time t

Model definition

In the empirical literature, the GARCH model considers the conditional variance to be a linear combination between square of residual and a part of the leg of conditional variance and the

Generalized Autoregressive Conditional Heteroscedasticity (GARCH) of Bollerslev (1986) suggested the generalized ARCH of Engle (1982).

Mathematically, we can write the model equation of a GARCH (p,q) as :

$$h_t = \alpha + \sum_{i=1}^{q} b_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} c_j h_{t-j}^2 \qquad (2)$$

Where $a > 0, b_i \geq 0, c_j \geq 0 \forall i, \forall j$

Where aa variance in long-term is, $\sum_{i=1}^{q} b_i \varepsilon_{t-i}^2$ is squared of residual and $\sum_{j=1}^{p} c_j h_{t-j}^2$ is the leg of conditional variance.

The aim of developing the multivariate GARCH models is to make GARCH models more parsimonious, the most multivariate GARCH is BEKK, RiskMatrics, CCC and DCC GARCH, Orthogonal GARCH.

Alexander (2001) define the Orthogonal GARCH (1, 1, m) model as:

$$y_t = \mu_{t+\varepsilon t} \qquad (3)$$

$$\varepsilon t = V^{\frac{1}{2}} \mu_t \qquad (4)$$

$$\mu_t = Z_m f_t \qquad (5)$$

Where V = diag (v_1, v2,…,v_N), with v_i the population variance of ε_{it}, and Z_m is a matrix of dimension N × m given by:

$$Z_{m} = P_m L_{m1/2} = P_m \, diag\,(f_t^{1/2} \ldots f_m^{1/2}), \quad (6)$$

$l_1 \geq \ldots \geq l_m > 0$ being the m largest eigenvalues of the population correlation matrix of ε_t and P_m the N × m matrix of associated (mutually orthogonal) eigenvectors. The vector $f_t = (f_{1t} \ldots f_{mt})'$is a random process such that:

$$E_{t-1}(f_t) = 0 \text{ and } Var_{t-1}(f_t) = \sum_t = diag\,(\sigma^2 f_{1t} \ldots \ldots \sigma^2 f_{m\,t}) \qquad (7)$$

$$\sigma^2 f_{it} = (1-\alpha_i - \beta_i + \alpha_i f^2_{\ t-1} + \beta_i \sigma^2 f_{it-1} \quad i=1,\ldots m \quad (8)$$

Consequently,

$$H_t = Var_{\,t-1}(\epsilon_t) = V^{1/2} \; V_t \, V^{1/2} \text{ where } V_t = Var_{\,t-1}(u_t) = Z_m \sum_t Z'_m \quad (8)$$

The parameters of the model are V, L_m, and the parameters of the GARCH factors (α_i's and β_i's). The number of parameters is N= (N+5)/2 (if m = N). In practice, their sample counterparts replace V and Lm, and the principal component analysis applied to the standardized residuals $\hat{u}_t$ determine m.

Results and discussion

Table 1 presents descriptive statistics of stock market index. The mean of markets return is equal to the median. We note that the kurtosis coefficients are a normal value (more than 3). We note

also the higher standard deviation that gives up uncertainty and instability in stock markets. Moreover, skewness coefficients were different from zero and negative, while, it indicates a non-symmetric series. The Jarque-Bera test is significant, which mean Brent indices are a normal distribution.

Table1**.** *Descriptive statistics of stock market returns*

	Germany	USA	UK	RUSSIA	china
Mean	0,000	0,000	0,000	-0,002	0,001
Median	0,001	0,000	0,000	-0,001	0,003
Maximum	0,049	0,038	0,035	0,096	0,054
Minimum	-0,048	-0,040	-0,048	-0,126	-0,089
Std. Dev.	0,014	0,009	0,010	0,028	0,024
Skewness	-0,082	-0,196	-0,372	-0,209	-1,062
Kurtosis	3,686	5,749	5,628	4,776	5,489
Jarque-Bera	5,163	80,022	77,408	34,533	111,110
Probability	0,006	0,000	0,000	0,000	0,000
Observations	249	249	249	249	249

Table 2 presents descriptive statistics of energy prices. In addition, we note the kurtosis coefficients are more than 3. We observe also the higher standard deviation, while the skewness coefficients were different from zero and indicate a non-symmetric series. The Jarque-Bera test is significant, which mean Brent indices are a normal distribution.

Table2**.** *Descriptive statistics of Energy prices returns*

	WTI	KERO	PRO	DIES	OILNY
Mean	-0,003	-0,003	-0,004	-0,002	-0,002
Median	-0,004	-0,004	0,003	-0,002	-0,003
Maximum	0,098	0,085	0,112	0,078	0,122
Minimum	-0,111	-0,082	-0,148	-0,090	-0,114
Std, Dev,	0,027	0,025	0,036	0,023	0,026
Skewness	0,087	0,241	-0,303	-0,135	0,153
Kurtosis	4,581	4,334	5,545	5,460	7,308
Jarque-Bera	25,808	20,880	70,990	63,552	193,518
Probability	0,000	0,000	0,000	0,000	0,000
Observations	249	249	249	249	249

It is necessary to examine Heteroscedasticity test. The ARCH LM test indicates the presence of ARCH effects of all dataset returns and allows the M-GARCH-class models become pertinent to model conditional correlation between energy prices and stock market returns.

Table 3. *Eigenvectors for stock market and energy price returns*

Component	Eigenvalue	Cumulative
DAX	3.8717	0.38717
Russia	1.5718	0.54435
SP500	1.1230	0.65665
Shanghai	0.84959	0.74161
UK	0.76680	0.81829
WTI	0.56962	0.87525
NYH Oil	0.53786	0.92903
NY Diesel	0.38639	0.96767
Kerosene	0.21604	0.98928
TX Propane	0.10724	1.0000

Table 3 shows Eigenvectors from the size can be producing the principal components (see more Alexander 2000, 2001, 2002). The results appear that the market index explains 81% of the total variation proportion. The energy prices together explain 29% of the total variation, which implies that a market index are highly correlated with one another compared the energy prices.

Table 4. *Correlation between PC and the variables*

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7
DAX	0,090	-0,626	-0,091	0,613	0,443	0,066	0,076
Russia	0,641	-0,350	0,251	-0,162	-0,002	-0,357	0,453
SP500	0,413	-0,628	0,260	-0,006	-0,248	-0,269	-0,480
Shanghai	0,036	0,099	0,926	0,099	0,030	0,338	-0,003
UK	0,151	-0,681	-0,177	-0,545	0,095	0,418	0,027
WTI	0,898	0,158	0,009	0,031	0,078	0,023	0,055
NYH Oil	0,813	0,193	-0,228	0,089	0,121	0,106	-0,223
NY Diesel	0,919	0,226	-0,081	0,027	0,069	0,074	-0,079
Kerosene	0,767	0,254	0,103	-0,219	0,258	-0,071	-0,018
TX Propane	0,597	-0,103	-0,158	0,288	-0,638	0,231	0,191
Total correlation	5,326	-1,460	0,814	0,217	0,205	0,560	0,001

Table 4 presents the correlation between the principal components and the variables for detecting whom each the PC is used to forecast the conditional mean. However, the correlation of range PC 1 appear the better compared to others. (See also table 5 of 10 time horizon out-of-sample forecasts for the conditional mean.).

Table 6. *Volatility persistence of four principal components*

PC	volatility	%
Part: PC(1)	ARCH(Alpha1)	-2,2421
	GARCH(Beta1)	104,405
	GJR(Gamma1)	4,5212
Part: PC(2)	ARCH(Alpha1)	28,9269
	GARCH(Beta1)	71,0658
	GJR(Gamma1)	-8,7691
Part: PC(3)	ARCH(Alpha1)	22,5402
	GARCH(Beta1)	83,0096
	GJR(Gamma1)	-15,3194
Part: PC(4)	ARCH(Alpha1)	21,9181
	GARCH(Beta1)	68,3562
	GJR(Gamma1)	13,7805

We note again in the next test that all returns, estimating are statistically significant and high persistence of shocks in the volatility (ARCH (Alpha1), GARCH (Beta1) and GJR (Gamma1) Finally, the test is present conditional correlations between energy prices and stock market returns (Figure 4). The main funding indicates a significant correlation of stock markets for emerging markets (Russia and China) and energy prices; WTI crude, kerosene and propane. We establish a positive correlation between Shanghai index and almost energy price especially WTI prices. Highest correlation is documented between S&P 500 and energy price during the end and star period, estimating , when it's shown negative in the middle period. Thus, UK, present the lowest conditional correlation between energy and FTSE indices while the DAX index having mixed correlation during the last year.

Conclusion

This study involves 249 observations covering a period from last year September 2014 to August 2015, when energy prices characterized by a decline. This study aims to investigate how major stock market index correlated to energy price decline. However, we find strong evidence of stock market index having mixed correlation to energy price during last years. The high oil price Orthogonal GARCH coefficient is very magnitude to correlate for US, China and Russia stock market, which maximizes the bilateral causality between two variables. The Orthogonal GJR-GARCH in the MENA countries indicates the dominant of oil price on stock market return volatility. The Orthogonal GJR-GARCH in the rest region shows minor effect between Oil Price and the Stock Markets compared the first regions.

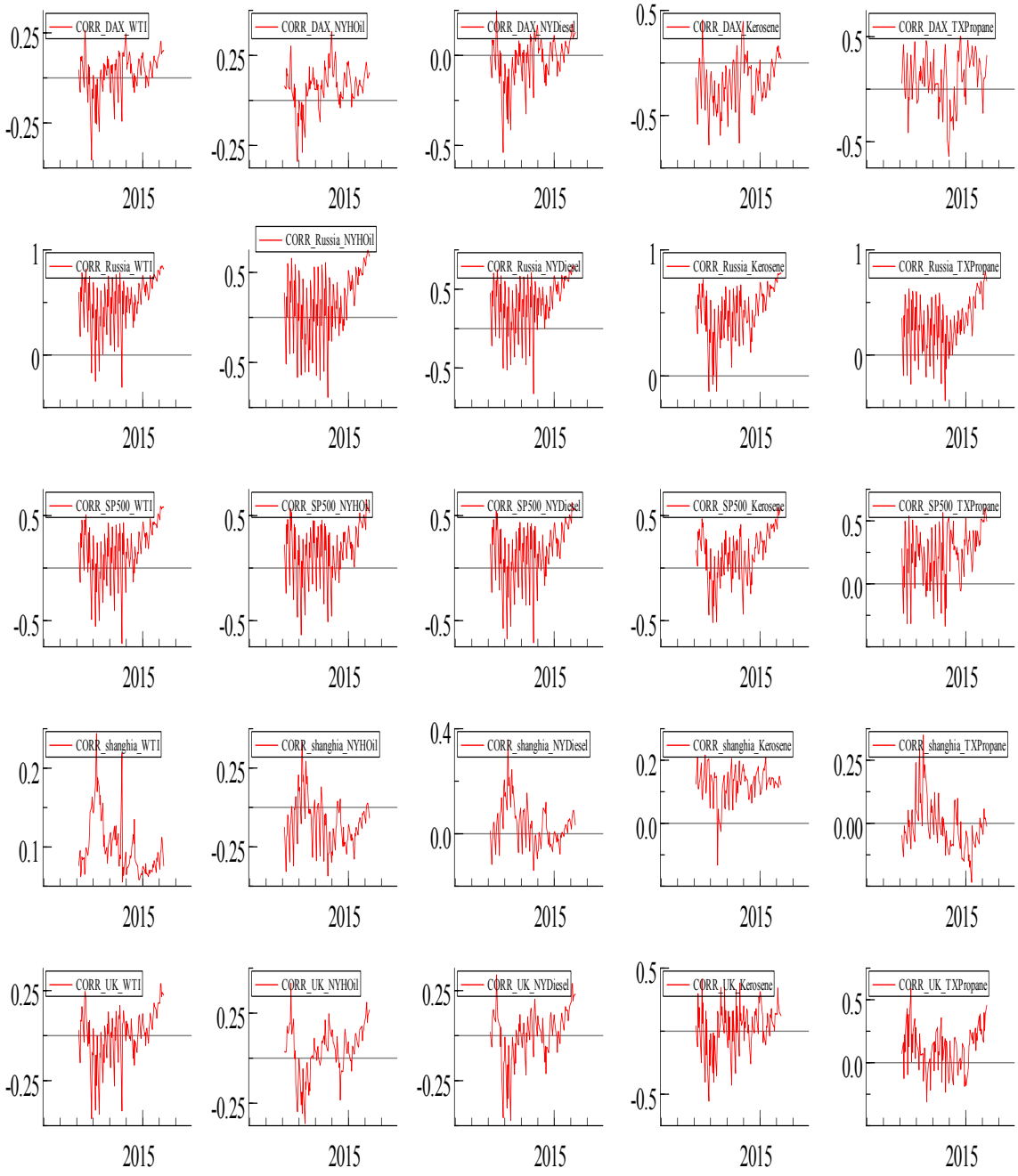

Figure 4: Conditional correlation using orthogonal GJR-GARCH

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